Final Report

Matching Plant-level data from the ABI/ARD with the Employee Skills Survey, 2001

Submitted to the DTI by

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Executive Summary

E1. This report details the results of the plant level matching of the Employers' Skills Survey (ESS) with the Annual Business Inquiry (ABI). Both datasets are held by the ONS, and matching has taken place previously; however, the nature of the initial matching process limited analyses to reporting units that were single plant enterprises. Following a short description of the matching procedure, the data have been described and some preliminary analysis has been conducted, to demonstrate the usefulness of such combined data.

E2. We found that Inter-Departmental Business Register (IDBR) numbers were only available from the ONS for 2001, which meant that we could only consider 2001 matching. For this year, the plant level matching procedure was successful in that more matches than previously had been found were identified.

E3. At first glance, the number of plant level matches is not substantially greater than previous matching exercises conducted. However, the matches obtained here include a considerable proportion of multi-plant enterprises, plants for which the ABI contains more financial data. It has therefore been possible to obtain a more representative cross-survey sample than was previously available.

E4. In addition to more representative underlying data, we weight the combined dataset, to make the findings representative of the underlying population of plants, in both manufacturing and the service sector. The weighted data indicate that the plants in the ESS/ABI are generally larger than those in the full ABI, and this relative over-representation of the larger plants should be borne in mind when any analysis is conducted. In line with expectations, foreign owned plants are larger and have higher levels of labour productivity. Labour productivity is

also found to be highest in the West Midlands, London and the South East of England.

E5. Using a sub-set of the merged ESS/ARD dataset, a preliminary productivity modelling exercise was undertaken for English manufacturing. The model was augmented by terms derived from the ESS, relating to skills gaps, qualifications, innovative activity and capacity utilisation. In this way, human capital and plant level attributes that were not previously available have been incorporated into productivity analysis.

E6. The findings indicate that plants operating below capacity are around 19 per cent less productive, and plants that regard themselves as innovators are almost 13 per cent more productive. Plants with perceived skills gaps are less productive and plants with a higher qualified workforce are marginally more productive; findings that are in line with expectations. Some further refinements to the modelling were tried, by interacting the human capital terms with other production function variables. We find that skills gaps have a more significant negative impact in some industries and that higher qualifications do not result in positive impacts across all industries. Innovative plants do seem to benefit from a more qualified workforce, with productivity 5 per cent higher.

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1. Introduction

1.1 The benefits from microeconometric analysis of plant level datasets are well documented (Griffith, 1999; Harris, 2002). Such analysis has also been used to inform government policy (Harris and Robinson, 2002a; 2002b). Much of this work for the UK has been based on the Annual Respondents Database (ARD), which has been used to large extent for productivity modelling. There are a number of other datasets held by the ONS that have valuable information at the plant or enterprise level. The Employers Skills Survey (ESS) is one such survey, which has been the source of a number of studies on workplace practices and characteristics (Mason et al, 2003).

1.2 The ARD contains no direct information on the human capital attributes of the workforce and therefore cannot be readily used to consider such issues as whether plants that employ more skilled workers benefit in terms of higher levels of (total factor) productivity. The Employers Skills Survey datasets for 1999 and 2001 have previously been merged with the ARD (see Hawkes, 2002) for use in analysing the impact of skills on productivity (see, for example, Haskel et. al., 2003). Thus, the merging of the ESS and ARD produces a potentially significant resource for conducting appropriate micro-level analysis of the link between TFP and the quality of the workforce employed in UK firms.

1.3 The ESS is obtained from sampling plants (i.e. local units)[1], so a large multi-plant company included in the ESS is very likely to have only some of its plants included. The ARD contains information at three major levels of aggregation: the enterprise (covering all plants in the organisation); the reporting unit level (these are accounting units which firms use to report back to the ONS and they can cover any number of plants in a multi-plant organisation); and the plant (or local unit). Harris (2002, 2004) provides a discussion on the strengths and weaknesses of using the different levels within the ARD, arguing that for most types of analysis the plant (or enterprise, in the case of single plant enterprises) is the appropriate unit of analysis, and not reporting units (when these belong to multi-plant enterprises).

[1] Details on the sample frame used are provided in the documentation for the version of the dataset lodged at the ESRC Data Archive, University of Essex, accessible at http://www.data_archive.ac.uk

1.4 Since the ESS is based on plant-level data, it can be strongly argued that the ESS needs to be matched to plant-level ARD information. In this way, problems of skill levels (and other aspects of human capital) at the plant level being wrongly matched to productivity information at the reporting unit or enterprise level may be avoided. Unless it is assumed that all plants in an organisation have the same human capital characteristics (as represented by just those plants included in the ESS), merging ESS plant level data at any other level of aggregation could lead to potentially biased outcomes.

1.5 The merging of the ESS and ARD undertaken by Hawkes (2002) for CeRiBA was based on an exercise conducted by the ONS (Newport) whereby the DfES originally supplied the ONS with a list of firm names, addresses and postcodes for various ESS surveys and the ONS used a software programme to search for matches to locate the appropriate inter-departmental business reference (IDBR) codes for the ESS samples. Unfortunately, the ONS only produced IDBR codes at the enterprise level, and not at local unit level. Thus, the ESS could only be matched at the enterprise level in the ARD, and therefore unless the enterprise comprises a single plant enterprise, there is a problem of matching at different levels of disaggregation discussed above. Working with the 2001 ESS, of the original 17,110 matches found by the ONS (at enterprise level), only some 2,313 comprised single-plant enterprises with financial and employment information (see Table 5 in Hawkes, 2002). This is likely to have hampered any analysis subsequently undertaken.

1.6 The purpose of this project is to attempt to match plant level ABI/ARD data with the ESS. (Originally, it had been intended to do this using ESS data for 1999 and 2001, but the 1999 data was not available to us on the Business Data Linking (BDL) server at ONS.) Thus based on the 2001 data, it was hoped at the outset that this would produce more matches than the 2,313 obtained by Hawkes. More importantly, the matched data should be significantly more representative of the population of plants operating in the UK economy, since by matching at the plant level we will include multi-plant enterprises (and not just single-plant enterprises) who contribute proportionately a larger amount to UK GDP and make up a significant proportion of the ‘selected’ files which contain financial data in the ABI.

1.7 Having obtained a more representative matched database, the Tender Document for this project proposed that we should firstly consider such important factors as weighting the data to make it representative for hypothesis testing. This should provide information on how useful the amended ESS/ARD merged dataset set is to answer questions and look at issues of national and sub-national importance in relation to the importance of human capital in determining plant level productivity in various manufacturing and non-manufacturing sectors of the UK economy. To this end, it was intended at the outset that we should conduct some exploratory statistical analysis of how skills/training impact on plant level productivity.

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2. Matching the ESS with the ARD

2.1 As noted in the last section, the approach used by Hawkes (2002) was to match the ARD and the ESS using the IDBR codes matched at the enterprise level. Consequently, only some 2,313 matches were obtained comprising single-plant enterprises with financial and employment information (according to Hawkes, *op. cit*., Table 5, a further 546 reporting units were matched but these comprised data from the ARD covering more than one local unit[2]). Of these, some 834 are reported to belong to the manufacturing sector.[3]

2.2 The approach to matching used here took the original 17,110 ESS/IDBR matches for 2001 found by the ONS (at enterprise level), and attempted to locate the actual plant in the ARD that matched the ESS plant surveyed. To do this, the first step was to take those 17,110 plants[4] in the ESS that had IDBR enterprise reference codes and then for each enterprise match the industry SIC (at the 5-digit level) and postcode information in the ESS to the industry SIC and postcode information at plant level available in the 2000 ARD[5]. This produced 9,382 unique plant level matches between the ESS and ARD.

2.3 Thus there were some 7,550 observations with potential matches at the enterprise level between the ESS and ARD, but for which no unique match could be found when using (5-digit) industry SIC and (8-element) postcode data. Thus, using employment information from both datasets, plus the industry SIC and postcode information, a manual checking exercise was undertaken to locate more matches between the ARD and ESS. This produced a further 1,068 observations that had not been uniquely computer matched using industry SIC and postcode information but which we are fairly certain are unique matches. Usually the industry SIC matched perfectly, but postcodes were only correct for the first 4 or more elements (with employment information from both datasets being used to verify that the correct plant was being matched). In total then, we

[2] That is, 2,859 matches were found but only 2,313 comprised single-plant reporting units (or enterprises) for the 2001 ESS.
[3] Note, it is not clear why the study by Haskel *et. al.* (2003, Table 1), which uses the merged data produced by Hawkes, only has 319 matches in manufacturing comprising single-plant enterprises (and a further 340 matches comprising reporting units covering more than one plant in each RU).
[4] Although, note, we could only find 16,949 matches where the enterprise reference code and postcode in the ARD were uniquely matched to the ESS sample with IDBR code at enterprise level. That is, 161 'matches' comprised enterprises which featured in the ARD more than once at different postcode addresses.
[5] The 2000 ARD was used as the ESS sample was drawn based on the 2000 (and not the 2001) IDBR.

were able to match some 10,450 observations from the ESS uniquely into the ARD at the plant level. It should be noted that our approach is unlikely to be as good as that which could be obtained by the ONS if they were to match the ESS (using names and addresses) to the IDBR *at the local unit level*. But the ONS did not match at this level for Hawkes and CeRiBA, resulting in our having to use what information is available in the ESS and the ARD to try to match at the plant level.

2.4 Of the 10,450 matched ESS/ARD plant level observations, 3,417 comprised of plants that had been selected for inclusion in the ABI(2) and thus have financial and employment information with which to undertake productivity analyses. Of these, some 840 are in manufacturing.

2.5 When compared to Hawkes (2002, Table 5), it might seem that we have not managed to obtain many more matches than originally obtained by the CeRiBA team. However, as will be shown in the next section, our matched ESS/ARD database comprises mostly plants that belong to multi-plant enterprises, which leads us to argue that we have probably obtained a much more representative sample compared to that used by Hawkes (2002) and in subsequent work by CeRiBA (cf. Haskel, *et. al.*, 2003).[6]

2.6 Moreover, we have calculated weights for our matched sample that is intended to ensure it is representative of the population of English plants covered by the ARD[7]. The importance and implications of weighting data for merged datasets is discussed in greater detail in Cheshire and Neisham (2004). The weights used in this dataset have been calculated using the following method: Based on employment data at the 2-digit SIC level, we calculate the total employment of the population of plants for each industry, and separately the total employment covered by those plants that are both included in the selected ARD sample (wit financial data) and in the ESS. The ratio of total population to sample employment for each industry provides a population weight with which to gross up the matched ESS/ARD sample to ensure it represents all the plants in each industry. Therefore, analysis based on weighted data can be regarded as representative of the distribution of plants in England.

[6] That is, of the 17,110 ESS plants matched at the enterprise level that both Hawkes and this project started out with, our 3,417 matches at plant level with financial data are likely to be a different sub-set of the ARD compared to the 2,859 matches at reporting unit level obtained by Hawkes.

[7] For a more detailed discussion of the need for weighting see Harris (2002).

3. Initial analysis of the merged dataset

3.1 In order to give some indications of how the 3,417 plants are distributed across certain key variables (such as whether they are single-plant enterprises, by region and by industry), some basic descriptions of the merged dataset comprising ABI(2) information are presented in Table 3.1,. Note the data in Table 3.1 have been weighted to ensure they are representative of the underlying population of plants (see par. 2.6).

3.2 Given that the average size of plants, covered in the matched ESS/ARD dataset with financial information from the ABI(2), is around 135 employees and £15.2m real gross output overall, this dataset covers larger plants than would typically be found in the full ABI(2) dataset within the ARD. Part of the reason is because (as seen in Table 3.1) the merged dataset covers a higher proportion of multi-plant enterprises than would be typical of the plants included in the much larger ARD.

3.3 As expected, foreign-owned plants are on average larger with much higher levels of labour productivity (obtained when dividing real gross output by employees). The latter is highest in the West Midlands, followed by London and the South East.

3.4 While this merged dataset has good coverage of the English regions and includes a representative sample of the industries included in the ARD, the above point that it is biased towards larger plants (and enterprises) needs to be kept in mind when undertaking any analysis with the data.

3.5 We have also undertaken some basic preliminary productivity modelling of the manufacturing sector sub-set of the merged ESS/ARD dataset. The analysis is limited to manufacturing because capital stock estimates (taken from Harris, 2005) are only available for this sector.

3.6 Initially we estimated the following simple Cobb-Douglas production function using the weighted data in the ESS/ARD for manufacturing:

$$y = \alpha_0 + \alpha_E e + \alpha_K k + \alpha_{AGE} age + \alpha_{US} US + \alpha_{FO} FO + \sum_{i=1}^{20} \beta_i SIC_i \qquad (3.1)$$

Table 3.1 Weighted mean values of the merged ESS/ARD plant level dataset

Variable	Plant level Employment	Real gross output (£'000 1990 prices)	n
Multi-plant enterprise	129	15502	2590
Single-plant enterprise	153	14387	837
North East	90	9029	225
Yorkshire-Humberside	135	13141	327
North West	140	14291	391
West Midlands	166	24169	406
East Midlands	127	10573	329
South West	137	13328	368
South East	129	16730	543
Eastern	128	11826	359
London	141	18327	475
UK-owned	127	11748	3131
US-owned	292	70604	96
Other foreign-owned	186	43012	200
Industry 1992SIC			
14	37	4651	10
15	304	37195	113
16	173	24948	25
18	99	5430	11
21	136	21252	28
22	166	22409	62
24	190	36416	62
25	132	11578	56
26	138	10270	48
27	185	32461	35
28	79	6177	79
29	204	21994	85
30	404	142967	10
31	168	11404	43
32	225	25635	20
33	151	12641	35
34	387	102592	40
35	361	40295	25
36	213	17906	34
45	91	13453	160
50	58	12157	66
51	108	32686	212
52	126	13094	537
55	54	2866	481
60	163	11433	72
63	135	18523	72
64	120	6345	122

70	66	6427	59
71	64	7545	45
72	207	21875	29
74	120	9598	277
75	112	Na	11
80	328	3488	150
85	89	2055	104
90	148	13749	10
91	75	4029	22
92	85	6305	97
93	55	2740	17
14	37	4651	10
15	304	37195	113
16	173	24948	25
18	99	5430	11
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where *y* refers to the logarithm of real gross value added (i.e. gross output minus intermediate inputs); *e* refers to the logarithm of employment (with α_E measuring the elasticity of output with respect to employment – i.e.$\partial y/\partial e$); *k* refers to the logarithm of capital stock (with corresponding elasticity of output, α_K); and *age* is the log of the age of the plant (in years). The US and FO variables take on a value of 1 if the plant is US- or other foreign-owned. Finally, there are up to 20 dummy variables covering the major 2-digit industry SIC's. A stepwise weighted OLS approach was used to estimate equation (3.1), with the results reported in the column labelled (1) in Table 3.2.

Table 3.2 Weighted OLS regressions using the ESS/ARD dataset for 2000

RHS variables[a]	Standard model (1)	Model (1) + ESS variables (2)	Model (2) + interaction Skill variables (3)
ln capital	0.236	0.236	0.246
	(0.052)***	(0.047)***	(0.053)***
ln labour	0.779	0.779	0.761
	(0.073)***	(0.067)***	(0.073)***
ln age	-0.175	-0.167	-0.173
	(0.050)***	(0.044)***	(0.051)***
SIC8	0.301	0.326	
	(0.112)***	(0.113)***	
US-owned	0.143		
	(0.090)		
Other foreign-owned	0.135		
	(0.089)		
SIC3	-0.295	-0.256	
	(0.166)*	(0.166)	
Skill		-0.171	-0.175
		(0.083)**	(0.081)**
Premium		0.139	0.215
		(0.050)***	(0.063)***
Qual		0.030	0.045
		(0.016)*	(0.020)**
Innovate		0.129	
		(0.047)***	
Underload		-0.186	
		(0.111)*	
SIC14		0.159	
		(0.076)**	
SIC13		0.168	
		(0.086)*	
SIC7		0.326	
		(0.186)*	
Premium x Skill			-0.228
			(0.098)**
SIC5 x Skill			-0.395
			(0.168)**
SIC4 x Qual			0.102
			(0.057)*
SIC13 x Skill			-0.367
			(0.142)***
Underload x Skill			-0.510
			(0.194)***
SIC6 x Qual			0.137
			(0.076)*
SIC13 x Qual			-0.091
			(0.035)***
SIC9			-0.264
			(0.121)**
SIC19 x Qual			-0.081
			(0.037)**
SIC16			-0.238
			(0.092)***
NW region			-0.102
			(0.066)
SIC14 x Skill			-0.499
			(0.164)***

SIC5 x Qual			-0.207
			(0.042)***
SIC17			-0.307
			(0.162)*
SIC18			-0.497
			(0.214)**
SIC15 x Skill			-0.275
			(0.106)***
Innovate x Qual			0.049
			(0.015)***
SIC2			-0.196
			(0.080)**
SIC10 x Skill			-0.386
			(0.131)***
SIC14 x Qual			-0.097
			(0.030)***
SIC5			0.526
			(0.178)***
SIC6			-0.337
			(0.175)*
SIC3 x Qual			-0.160
			(0.054)***
SIC11			-0.226
			(0.106)**
n	820	820	820
R^2	0.76	0.77	0.78

Robust standard errors in parentheses (* significant at 10%; ** significant at 5%; *** significant at 1%)

[a] Definitions

Qual = most common Qualification for entire workforce ranging 0=none to 6=higher level
Skill = broad skill gap for entire workforce ranging 0=none to 1=all
Premium = coded 1 if quality product/service produced
Innovate = coded 1 if plant leads in developing products, processes in industry
Underload = coded 1 if plant working considerably below full capacity
Import = coded 0 if main supplier in UK and 1 if main supplier overseas

3.7 The results for the standard model are as expected, with slightly increasing returns to scale ($\alpha_E + \alpha_K > 1$). For older plants, *cet. par.*, doubling the age of a plant results in nearly an 18 per cent decrease in output (and thus TFP). US-owned plants are nearly 15 per cent more productive, while other foreign-owned are some 14 per cent more productive than UK owned plants. Only one industry dummy proved to be significant in this basic model, and then at only the 10 per cent level. Note, we did introduce a dummy variable to take account of whether the plant was a single plant enterprise or not, but found this was not significant, in any of the models we estimated.

3.8 Next the basic model was augmented to include variables drawn from the ESS. Specifically, we calculated a variable to measure whether a plant experienced a (broad) skill gap, based on the question in the ESS on whether all workers in 9 occupation groups had the relevant skills to do the job. Coding responses as 1 if

the respondent said there was a gap for any occupation, and then weighting the 9 occupation figures by the proportion of the workforce in each occupation group, gave an overall skill-gap figure.[8] The QUAL variable used is constructed in a similar way; for each occupation group respondents gave information on the most common qualification available (which we coded from 0 = none to 6 = highest level qualifications – i.e. postgraduate or equivalent level), and these were weighted by the proportion of the workforce in each occupation group to obtain an overall figure. Four other variables from the ESS were also included as potentially relevant: premium, underload, import and innovate (definitions are given at the end of Table 3.2).

3.9 The results for the augmented model are presented in the column headed model (2) in Table 3.2, showing that as expected skill gaps had a significant negative impact on productivity, while a better qualified workforce has a significant (although much smaller) positive effect on production. Plants operating considerably below full capacity are some 19 per cent less productive, while those that produce a quality product/service and/or lead with new innovations are between 12 and 15 per cent more productive, respectively. Note, the statistically significant foreign-ownership effects in the basic model are now absent, while many more industry differences now become important in the extended model.

3.10 The final model estimated attempted to link the SKILL and QUAL variables with the variables covering industry sector and those available from the ESS. Other composite variable combinations involving SKILL and QUAL could have been tried, and future work can undertake these additional calculations. The results from the current exercise are reported in the column headed model (3) in Table 3.2.

3.11 The results of model (3), associated with the model including composite dummy variables involving the skill and qualification variables, show that skill gaps have a more important negative impact in certain industries but that higher levels of qualifications do not always result in positive impacts for some industries. However, innovative plants appear to benefit from better qualified workforces, with productivity some 5 per cent higher in this instance.

[8] This variable ranged between 0 and 1, since the 0,1 responses for each occupation group are weighted by their share of total plant employment.

4. Summary and Conclusions

4.1 The aim of this project was to match the Employers Skills Survey (ESS) to the financial data contained in the Annual Business Inquiry (ABI) and undertake some preliminary analysis on the merged data. In contrast to the earlier matching work carried out by Hawkes (2002) and the analysis of Haskel et al (2003), this project matched at the plant level. We have argued that this is a more appropriate level to match given the nature of ESS data collection (local units) and the type of analysis for which these data would be used.

4.2 The matching process was only possible for 2001 data, because of the IDBRs made available by the ONS. Whilst, the plant level matching process yielded more matches than those obtained by others, they are also more representative since the dataset contain a larger number of plants that operate as part of a multiplant organisation. Thus we are able to represent a larger number of plants that are contained in the selected files of the ABI/ARD, those plants that have financial data collected. In addition to the coverage achieved by the plant level matching, we also highlight the importance of population weighting the matched sample.

4.3 In terms of describing the matched dataset, we find that the plants included in the merged data set are generally larger than those in the full ABI, and the relative over-representation of the larger plants should be borne in mind when any analysis is conducted. We see that, in line with expectations, foreign owned plants are larger and have higher levels of labour productivity. Labour productivity is also found to be highest in the West Midlands, London and the South East of England.

4.4 In this report we have conducted a preliminary analysis, demonstrating the usefulness of the ESS/ABI merged dataset, using a Cobb-Douglas production function for English manufacturing. Following on from a standard model, we augment the basic production function with terms derived from the ESS. The variables used include perceived skills gaps within the plants, the level of qualification held by the workforce, the degree of innovation within the plant and whether the plant is operating considerably below full capacity. The results indicate that plants operating below capacity are around 19 per cent less productive, and plants that regard themselves as innovators are almost 13 per

cent more productive. Plants with perceived skills gaps are less productive and plants with a higher qualified workforce are marginally more productive; findings in line with expectations.

4.5 Attempts to interact skills gaps and qualification terms with other production variables has shown some interesting results, and this may be an area for further research. Our initial estimates indicate that skills gaps have a more significant negative impact in some industries and that higher qualifications do not result in positive impacts across all industries. Innovative plants do seem to benefit from a more qualified workforce, with productivity 5 per cent higher

4.6 Overall, it can be seen that the plant level matching procedure linking the ESS to the ABI has been successful for 2001. This has yielded an interesting dataset which allows for skills and qualifications considerations to be included in productivity analysis. There are limitations to its application; the ESS covers only England, it has only been possible to match it to the ABI for a single year (2001), and it is biased towards larger plants and enterprises. In addition, the limited availability of capital stocks data means that total factor productivity analysis is only possible for manufacturing. However, these data allow for a more refined analysis of labour market factors, such as training, qualifications and skills gaps, than has been previously possible. These are important factors, and are likely to be of particular interest from a policy perspective.

4.7 Our preliminary research highlights some of the issues that may be considered with these data. In particular, the impacts that skills shortages and workforce qualifications have on plant level productivity in English manufacturing may provide a useful insight into the impact of training and skills policies developed by government, or may provide information on skills shortages that might be appropriately targeted by future government policies.

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